CCTF 2009: Report of the Royal Observatory of Belgium

P. Defraigne
Royal Observatory of Belgium

Clocks and Time scales:

The Time Lab of the Royal Observatory of Belgium (ROB) contains presently 3 Cesium clocks HP5071A with standard tubes (since 1993 and 1995), two active H-maser : CH1-75 (since 1991) and CH1-75A (since 2006). The time laboratory temperature variations are kept smaller than 0.2°C.
During the period 2006-2009, the UTC(ORB) time scale was generated from the frequency of the H-maser CH1-75, of which the auto-tuning is based on the 5Mhz frequency from the H-maser CH1-75A. The monitoring of UTC(ORB) is performed daily from a comparison with the USNO Master Clock MC2 used to steer the USNO Ashtech Z-XII3T receiver (IGS station USN3). This comparison is done using the self-developed software Atomium based on a Precise Point Positioning approach, using IGS rapid and ultra-rapid orbits and clocks. The behavior of UTC(ORB) with respect to UTC is shown in Figure1.

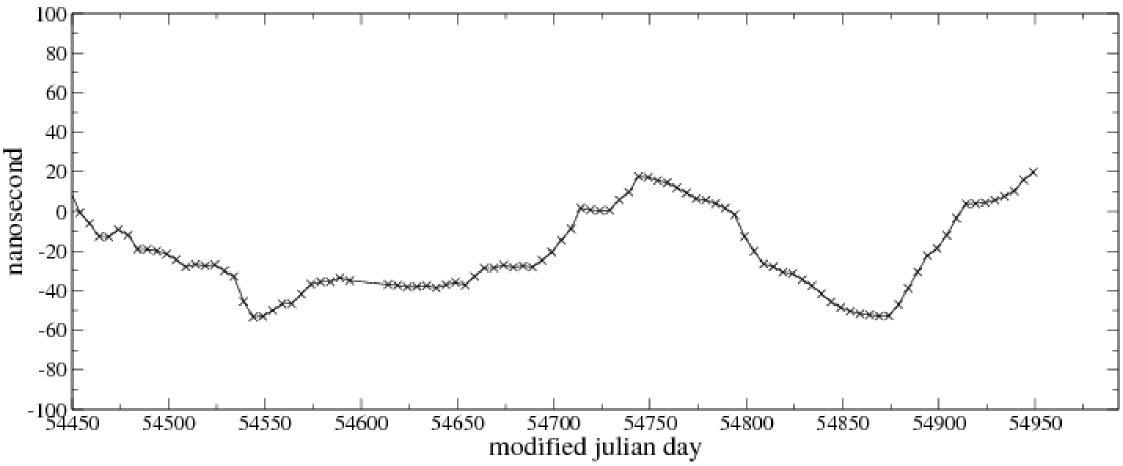

Figure 1. UTC-UTC(ORB) from 2004.0 to 2006.5

GPS Time transfer using geodetic receivers

The software **R2CGGTTS** developed at ROB for giving CGGTTS files from RINEX files has been updated, up to the present version V4.3; this last version includes the possibility to be applied on data from receivers measuring C1 and P2 rather than P1 and P2; it also proposes a new troposphere correction, which accounts for the station altitude dependence. The new version also compute for an additional 13-minute track when a 90th track begins inside the day. Some other changes have been introduced in the structure by Septentrio, but these have no impact on the results.

The software called **Atomium,** developed for using code and carrier phase measurements in PPP mode as well as in single difference mode, using IGS satellite clocks and orbits, has been further developed. From the comparison with other PPP software, its quality has been shown to be equivalent to the quality of the other ones. It was also upgraded in order to perform:

- **phase-only analysis**, in which case only the carrier phase data are used. This ensures the continuity of the clock solutions across the day boundaries, but the drawback is that a drift is present in the signal. This drift is due to the fact that the position must be fixed when only the carrier phase data are used, and this position should be accurate at the mm level, which is presently not possible. The inaccurate fixed position is responsible for a drift in the continuous clock solution.
- Common analysis of **GPS and GLONASS** data. As both systems have no common reference time scales for their satellite clocks, only a single difference (common-view) approach can be used. We have shown that the GLONASS constellation (2008 status), when added to the GPS one, does not allow to improve the quality of the time and frequency transfer based on GNSS, compared to GPS only; it prepares us however for the future treatment of combined GPS+GALILEO data.
- We have developed a **combined least square analysis of GPS** measurements and **TWSTFT** data in order to get a combined solution of time transfer which takes advantage of the good calibration of the TWSTFT and the good stability of the GPS phase analysis. Our method consists in introducing the TW data as constraints (or new observation equations) in the least square model based on the single differences (or common view) of code and carrier-phase observations. We have shown a large improvement in medium and long baselines; the large day boundary jumps of the GPS-only solution, which are due to the colored noise of the GPS codes, are reduced in the combined GPS+TW solution; there are still some small discontinuities at the day boundaries due to the noise in the TW data.
- We have computed and quantified the **second and third order ionospheric perturbations on GPS signals** and their influence on time transfer, and we have included this correction in the new version of the Atomium software; In particular, we have shown that the third order effect is always at the picosecond level. The second order effects can be larger than 10 ps only for long East-West baselines (for which the noon solar maximum of ionospheric activity is not synchronized) and during periods of important solar activity. It was also shown that the second order effect can be very large (up to some nanosecond) during the geomagnetic storms, but due to the high space-time variability of the geomagnetic field at that time, the correction cannot be computed during these storms storms.

Collaboration with the International Astronomical Union (IAU):

P. Defraigne was President of the IAU Commission 31 (TIME) during the period 2006-2009; with the collaboration of some members of this commission and others, we prepared a Joint Discussion about “Time and Astronomy” during the next General Assemble, in August 2009. http://www.astro.oma.be/IAU/COM31/jd6.php.

Some associated References:

- P. Defraigne, C. Bruyninx, “On the link between GPS pseudorange noise and day-boundary discontinuities in geodetic time transfer solutions”, *GPS solutions*, 11(4), pp. 239-249, (2007).
- P. Defraigne, N. Guyennon, C. Bruyninx, “GPS Time and Frequency Transfer: PPP and Phase-only analysis”, *Intern. Journ. of Navigation and Observation*, Volume 2008 (2008), Article ID 175468.
- Q. Baire, P. Defraigne, “Combining GPS and GLONASS for Time and Frequency Transfer”, Proc. 28th EFTF, CD-rom, 2008.
- P. Defraigne, C. Bruyninx, J. Legrand, “Continuous frequency transfer using GPS carrier-phases”, Proc. 28th EFTF, CD-rom, 2008.
- P. Defraigne, M.C. Martinez, Z Jiang, “Time transfer from combined analysis of GPS and TWSTFT data”, Proc. 40th PTTI, CD-rom, 2008.
- S. Pireaux, P. Defraigne, L. Wauters, N. Bergeot, Q. Baire, C. Bruyninx, “Higher order ionosphere perturbations in GPS time and frequency transfer”, Proc. EFTF-IFCS 2009.